Year 9

The Material World

These note are a summary and should not be used in replace of regular class work

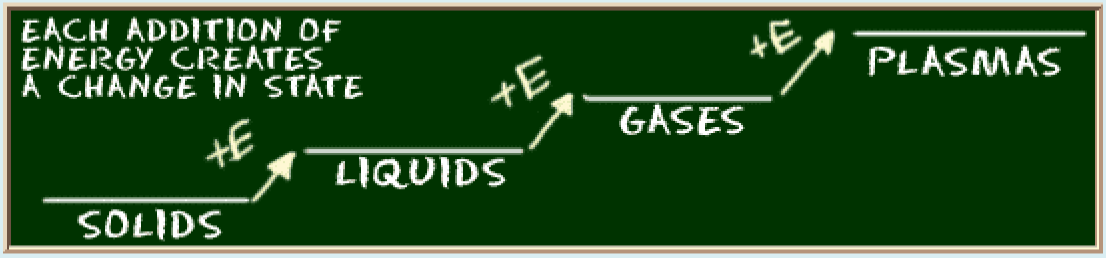
Contents

Matter is the Stuff around You

Matter is everything around you. **Matter** is anything made of molecules. Matter is anything that has a **mass**. Matter is also related to light and electromagnetic radiation. Even though matter can be found all over the universe, you usually find it in just a few forms.

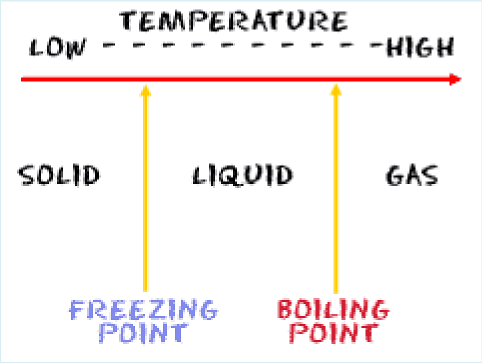
STATES OF MATTER

There are 3 main states of matter. Solids, liquids, gases are all different states of matter. Each of these states is also known as a phase. The phase or state of matter can change when the temperature changes. Generally, as the temperature rises, matter moves to a more active state.
Phase describes a **physical state of matter**. The key word to notice is **physical**. Things only move from one phase to another by **physical** means. If energy is added (like increasing the temperature or increasing pressure) or if energy is taken away (like freezing something or decreasing pressure) you have created a **physical change**.

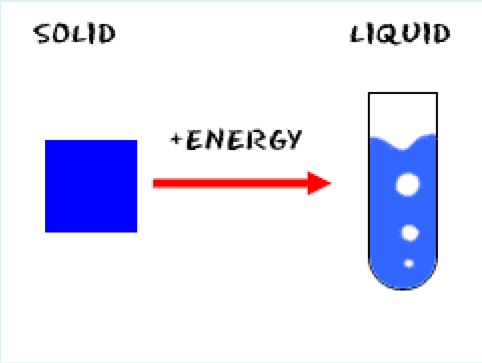


One compound or element can move from phase to phase, but still be the same substance. You can see water **vapour** over a boiling pot of water. That vapour (or gas) can **condense** and become a drop of water. If you put that drop in the freezer, it would become a solid. No matter what phase it was in, it was always water. It always had the same chemical properties.

Changing States of Matter



All matter can move from one state to another. It may require very low temperatures or very high pressures, but it can be done. Phase changes happen when certain points are reached. Sometimes a liquid wants to become a solid. Scientists use something called a **freezing point** to measure when that liquid turns into a solid. There are physical effects that can change the freezing point. Pressure is one of those effects.



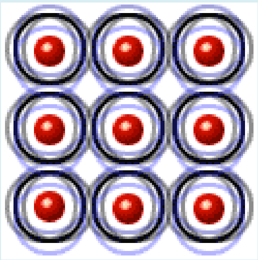
When the pressure surrounding a substance goes up, the freezing point also goes up. That means it's easier to freeze the substance at higher pressures. When it gets colder, most solids shrink in size. There are a few which expand but most shrink.

Now you're a solid. You're a cube of ice sitting on a counter. You dream of becoming liquid water. You need some **energy**. Molecules in a liquid have more energy than the molecules in a solid. The easiest energy around is probably heat. There is a magic temperature for every substance called the melting point. When a solid reaches the temperature of its melting point it can become a liquid. For water the temperature has to be a little over zero degrees Celsius. If you were salt, sugar, or wood your melting point would be higher than water.

The reverse is true if you are a gas. You need to lose some energy from your very excited gas molecules. The easy answer is to lower the surrounding temperature. When the temperature drops, energy will be sucked out of your gas molecules. When you reach the temperature of the condensation point, you become a liquid. If you were the steam of a boiling pot of water and you hit the wall, the wall would be so cool that you would quickly become a liquid.

SOLID BASICS

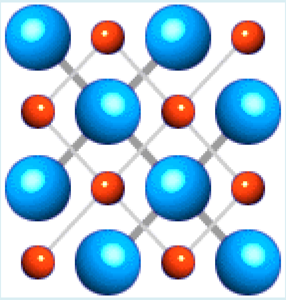
So what is a solid? Solids are usually hard because their molecules have been packed together. The closer your molecules are, the harder you are. Solids also can hold their own shape. A rock will always look like a rock unless something happens to it. The same goes for a diamond. Even when you grind up a solid into a powder, you will see little tiny pieces of that solid under a microscope. Liquids will move and fill up any container. Solids like their shape.



In the same way that a solid holds its shape, the molecules inside of a solid are not allowed to move around too much. This is one of the **physical** characteristics of solids. Molecules and molecules in liquids and gases are bouncing and floating around, free to move where they want. The molecules in a solid are stuck. The molecules still spin and the electrons fly around, but the entire molecule will not change position.

Solids can be made up of many things. They can have pure elements or a variety of compounds inside. When you get more than one type of compound in a solid it is called a **mixture**. Most rocks are mixtures of many different compounds. Concrete is a good example of a manmade mixture.

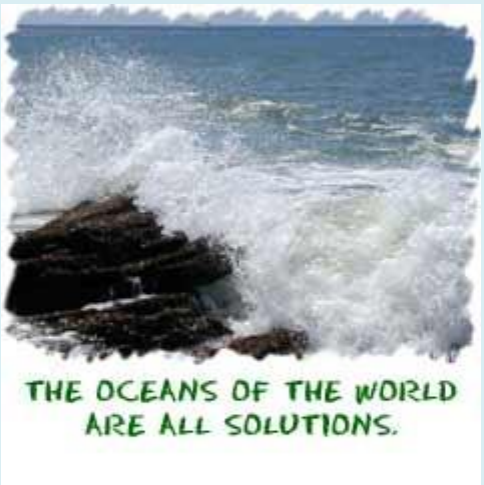
CRYSTALS



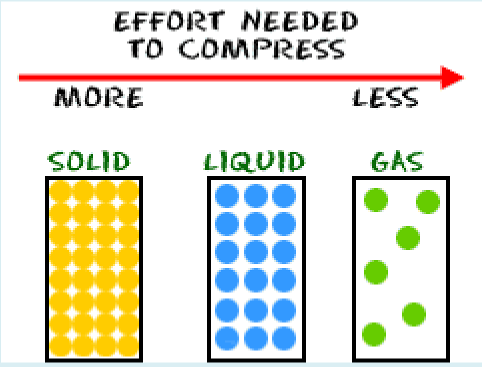
On the other end of the spectrum from a mixture is something called a crystal. When a solid is made up of a pure substance and forms slowly, it can become a crystal. Not all pure substances form crystals because it is a delicate process. The molecules are arranged in a regular repeating pattern called a crystal lattice. A crystal lattice is a very exact organization of molecules. A good example is carbon. A diamond is a perfect crystal lattice while the graphite arrangement is more random.

Liquid Basics

The second state of matter we will discuss is a liquid. Solids are hard things you can hold. Gases are floating around you and in bubbles. What is a liquid? Water is a liquid. Your blood is a liquid. Liquids are an in-between state of matter. They can be found in between the solid and gas states. They don't have to be made up of the same compounds. If you have a variety of materials in a liquid, it is called a solution.



One characteristic of a liquid is that it will fill up the shape of a container. If you pour some water in a cup, it will fill up the bottom of the cup first and then fill the rest. The water will also take the shape of the cup. It fills the bottom first because of **gravity**. The top part of a liquid will usually have a flat surface. That flat surface is because of gravity too. Putting an ice cube (solid) into a cup will leave you with a cube in the middle of the cup; the shape won't change until the ice becomes a liquid.

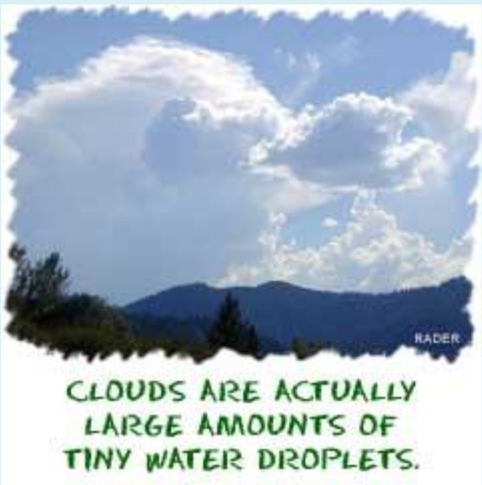


Another trait of liquids is that they are difficult to compress. When you compress something, you take a certain amount and force it into a smaller space. Solids are very difficult to compress and gases are very easy. Liquids are in the middle but tend to be difficult. When you compress something, you force the atoms closer together. When pressure goes up, substances are compressed. Liquids already have their atoms close together, so they are hard to compress. Many shock absorbers in cars compress liquids in tubes.

A special force keeps liquids together. Solids are stuck together and you have to force them apart. Gases bounce everywhere and they try to spread themselves out. Liquids actually want to stick together. There will always be the occasional evaporation where extra energy gets a molecule excited and the molecule leaves the system. Overall, liquids have **cohesive** (sticky) forces at work that hold the molecules together.

Looking for a Gas

Gas is everywhere. There is something called the atmosphere. That's a big layer of gas that surrounds the Earth. Gases are **random** groups of atoms. In solids, atoms and molecules are compact and close together. Liquids have atoms a little more spread out. However, gases are really spread out and the atoms and molecules are full of energy. They are bouncing around constantly.



Gases can fill a container of any size or shape. That is one of their physical characteristics. Think about a balloon. No matter what shape you make the balloon it will be evenly filled with the gas atoms. The atoms and molecules are spread equally throughout the entire balloon. Liquids can only fill the bottom of the container while gases can fill it entirely.

You might hear the term **vapor**. Vapor and gas mean the same thing. The word vapor is used to describe gases that are usually found as liquids. Good examples are water or mercury (Hg). Compounds like carbon dioxide are usually gases at room temperature so scientists will rarely talk about carbon dioxide vapour. Water and mercury are liquids at room temperature so they get the vapour title.

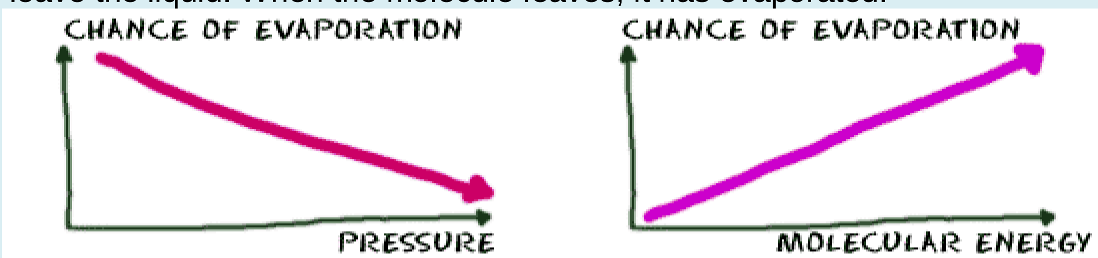
Gases hold huge amounts of energy, and their molecules are spread out as much as possible. With very little pressure, when compared to liquids and solids, those molecules can be **compressed**. It happens all of the time. Combinations of pressure and decreasing temperature force gases into tubes that we use every day. You might see compressed air in a spray bottle or feel the carbon dioxide rush out of a can of soda. Those are both examples of gas forced into a space smaller than it would want, and the gas escapes the first chance it gets.

Evaporation of Liquids

Sometimes a liquid can be sitting in one place (maybe a puddle) and its molecules will become a gas. That's the process called **evaporation**. It can happen when liquids are cold or when they are warm. It happens more often with warmer liquids. Evaporation is all about the energy in individual molecules, not about the **average energy** of a system. The average energy can be low and the evaporation still continues.

You might be wondering how that can happen when the temperature is low. It turns out that all liquids can evaporate at room temperature and normal air pressure. Evaporation happens when atoms or molecules escape from the liquid and turn into a vapor. Not all of the molecules in a liquid actually have the same energy.

The energy you can measure with a **thermometer** is really an average of all the molecules in the system. There are always a few molecules with a lot of energy and some with barely any energy at all. The molecules with a lot of energy are able to build up enough power to become a gas. Once they reach that energy level, they can leave the liquid. When the molecule leaves, it has evaporated.



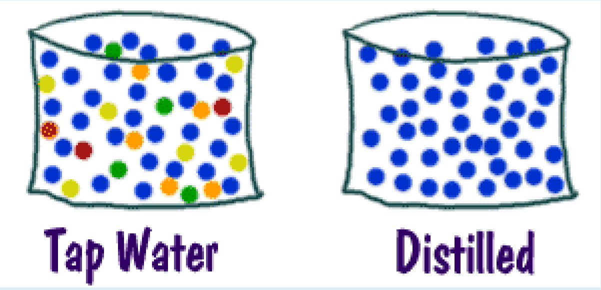
The rate of evaporation can also increase with a decrease in the gas pressure around a liquid. Molecules like to move from areas of higher pressure to lower pressure. The molecules are basically sucked into the surrounding area to even out the pressure.

Condensation of Liquids

Let's explain **condensation** first. Condensation happens when several gas molecules come together and form a liquid. It all happens because of a loss of energy. Gases are really excited atoms. When they lose energy, they slow down and begin to collect. They can collect into one drop. Water condenses on the lid of your pot when you boil water. It cools on the metal and becomes a liquid again. You would then have a condensate.

Mixture Basics

Mixtures are absolutely everywhere you look. Mixtures are the form for most things in nature. Rocks, air, or the ocean, they are just about anything you find. They are substances held together by **physical forces**, not chemical. That statement means the individual molecules enjoy being near each other, but their fundamental chemical structure does not change when they enter the mixture.



When you see **distilled water**, it's a pure substance. That fact means that there are just water molecules in the liquid. A mixture would be a glass of water with other things dissolved inside, maybe salt. Each of the substances in that glass of water keeps the original chemical properties. So, if you have some dissolved substances, you can boil off the water and still have those dissolved substances left over. Because it takes very high temperatures to boil salt, the salt is left in the container.

Mixtures are Everywhere

There are an infinite number of mixtures. Anything you can combine is a mixture. Think of everything you eat. Just think about how many cakes there are. Each of those cakes is made up of a different mixture of ingredients. Even the wood in your pencil is considered a chemical mixture. There is the basic cellulose of the wood, but there are also thousands of other compounds in that pencil.

Solutions are also mixtures. If you put sand into a glass of water, it is considered to be a mixture. You can always tell a mixture because each of the substances can be separated from the group in different physical ways. You can always get the sand out of the water by filtering the water away. A solution can also be made of two liquids. Even something as simple as bleach and water is a solution.

Mixtures around You

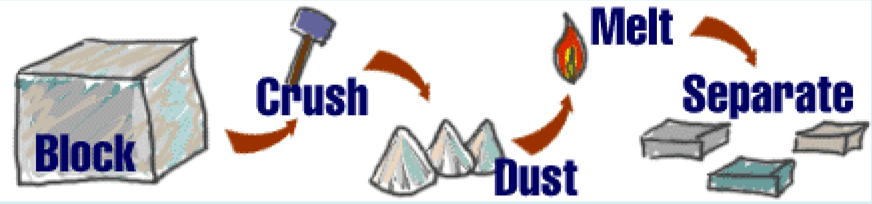
Two classic examples of mixtures are **concrete** and salt water. If you live near the ocean, they surround you every day. Even if you're inland, you need to remember your tap water also has many compounds inside, and they act the same way salt would. That is, concrete is a mixture of lime (CaO)/cement, water, sand, and other ground-up rocks and solids. All of these ingredients are mixed together. Workers then pour the concrete into a mold and the concrete turns into a solid (because of the cement solidifying) with the separate pieces inside.

While the cement hardening might be a chemical reaction, the rocks and gravel are held in place by physical forces. They are included in the mixture to increase the strength of concrete. The rocks and gravel are not chemically bonded to the cement. The gravel is also not evenly distributed. There are pieces of gravel here and there. The concentrations of gravel change from area to area. Salt water is different. First, it's a liquid. Second, it's an ionic solution. The salt is broken up into sodium (Na) and chloride (Cl) ions in the water.

A CLOSE LOOK AT SOME DRIED CONCRETE FROM A SIDEWALK.

You might be wondering why concrete and salt water are not new compounds when they are mixed together. The special trait of mixtures is that physical forces can still remove the basic parts. You can take the solid concrete and grind it up again. The individual components can then be separated and you can start all over. Salt water is even easier. All you have to do is boil the water off and the salt is left, just as if you never mixed the two compounds.

Putting Together and Breaking Apart



The thing to remember about mixtures is that you start with some pieces, combine them, and then you can do something to pull those pieces apart again. You wind up with the same molecules (in the same amounts) that you started with. The way you separate the molecules is as unique as the mixture. We have talked about grinding and boiling. If you have a mixture of salt and tiny pieces of iron, you could use a magnet to separate the iron from the mixture.